UNITED NATIONS

A

General Assembly

Distr.
GENERAL

A/AC.105/438
3 January 1990

ORIGINAL: ENGLISH

COMMITTEE ON THE PEACEFUL USES
OF OUTER SPACE

REPORT ON THE UNITED NATIONS INTERNATIONAL MEETING OF EXPERTS ON THE DEVELOPMENT OF REMOTE-SENSING SKILLS AND KNOWLEDGE, ORGANIZED IN CO-OPERATION WITH THE GOVERNMENT OF THE UNITED KINGDOM OF GREAT BRITAIN AND NORTHERN IRELAND AND HOSTED BY THE UNIVERSITY OF DUNDEE

(Dundee, United Kingdom, 26-30 June 1989)

CONTENTS

	Paragraphs	Page
INTRODUCTION	1 - 8	3
A. Background and objectives	1 - 4	3
B. Organization and programme of the Meeting	5 - 8	3
I. OBSERVATIONS AND RECOMMENDATIONS	9 - 44	4
A. Considerations of the Meeting	9	4
B. Effective use of existing remote-sensing technology and environmental data	10 - 22	5
1. Development of focal structures	10 - 14	5
2. National and regional inventories	15 - 17	7
3. Government and public awareness	18 - 19	8
4. Data acquisition, processing, interpretation and archiving facilities	20 - 21	8
5. Overcoming obstacles to the implementation of recommendations	22	9

90-00265 1299i (E)

/...

CONTENTS (continued)

	Paragraphs	Page
C. Skills and knowledge necessary to support and stimulate research in remote-sensing technology	23 - 44	10
1. Indigenous technological capability	23 - 26	10
2. Remote-sensing curricula within the educational system	27 - 28	11
3. Non-formal education	29 - 32	11
4. Acquisition of data	33 - 37	12
5. Applications and education	38 - 40	12
6. Centres of excellence	41	13
7. Communication, networking and information exchange	42 - 44	13
II. SUMMARY OF PRESENTATIONS	45 - 64	13
A. Attitudes and policies	45 - 49	13
B. Experiences gained and infrastructure needed	50 - 52	14
C. Education programmes and teaching aids for teachers	53 - 58	15
D. University programme for research and application professionals	59 - 64	16
Annex. Programme of the Meeting		18

INTRODUCTION

A. Background and objectives

1. The General Assembly, at its thirty-seventh session, adopted resolution 37/90 of 10 December 1982, endorsing the recommendations of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE 82) that the United Nations Programme on Space Applications should promote the growth of indigenous nuclei and an autonomous technological base in space technology at the local level. At its thirty-first session, in June 1988, the Committee on the Peaceful Uses of Outer Space endorsed the United Nations Programme on Space Applications for 1989 as proposed by the Expert on Space Applications and recommended by the Scientific and Technical Sub-Committee of the Committee at its twenty-sixth session. Subsequently, the General Assembly, at its forty-third session, endorsed the activities of the Programme on Space Applications for 1989 (resolution 43/56 of 6 December 1988).

2. The United Nations Meeting of Experts on the Development of Remote-Sensing Skills and Knowledge was part of the 1989 activities of the Space Applications Programme. The Meeting was organized in co-operation with the Government of the United Kingdom of Great Britain and Northern Ireland and was hosted by the University of Dundee, Scotland, from 26 to 30 June 1989.

3. The objective of the Meeting was to examine problems relating to the development of skills and knowledge as well as to the growth and application of space science and technology. The Meeting also examined the processes and issues associated with the introduction of elements of space science and technology into existing educational curricula, particularly in developing countries.

4. The present report, which covers the background, objectives and organization of the Meeting, as well as a summary of presentations, observations and recommendations made at the Meeting, has been prepared for the Committee on the Peaceful Uses of Outer Space and its Scientific and Technical Sub-Committee. Participants will report to appropriate authorities in their respective countries.

B. Organization and programme of the Meeting

5. Invitations to participate in the Meeting were sent by the United Nations to scientific and technical professionals with substantial experience in one or more of the following areas: (a) design of education curricula and related materials; (b) teaching, research and applications in space science and technology; and (c) pedagogy. The Meeting was attended by 44 experts from 18 countries and four international organizations. The participants in the Meeting came from Australia, Canada, Egypt, France, India, Indonesia, Kenya, Mexico, the Netherlands, Nigeria, Norway, Pakistan, Qatar, Saudi Arabia, Sweden, Thailand, the United Kingdom, the United States of America, the European Space Agency (ESA), the United Nations Educational, Scientific and Cultural Organization (UNESCO), the United Nations Environment Programme (UNEP) and the United Nations Outer Space Affairs Division.

6. Funds allocated by the United Nations for the organization of the Meeting were used to cover the cost of international air travel for 14 participants. The Government of the United Kingdom provided the funds that were used to defray the cost of subsistence allowances for participants from developing countries and the cost of conference facilities.

7. Welcoming addresses were presented by Prof. M. J. Hamlin, Principal and Vice-Chancellor of the University of Dundee, by Mr. P. H. D. Wetton, Head of the Energy, Science and Space Department of the United Kingdom Foreign and Commonwealth Office on behalf of the Government, and by Mr. A. A. Abiodun, Expert on Space Applications, on behalf of the United Nations. The keynote address was delivered by Mr. N. Press, NPA Ltd., United Kingdom.

8. The programme of the Meeting (see annex I) was developed by the United Nations Outer Space Affairs Division in collaboration with the University of Dundee. It was designed to provide the participants, through plenary presentations, with the opportunity to familiarize themselves with the various efforts that were being undertaken at the national and international levels to provide education and training in all aspects of remote-sensing technology and its applications. The programme included working group sessions where the participants discussed in depth the development of indigenous capability in remote-sensing technology and its applications with due regard for the educational, cultural and economic characteristics of the countries concerned.

I. OBSERVATIONS AND RECOMMENDATIONS

A. Considerations of the Meeting

9. The participants met in two working groups to address the following issues: (a) ways of making more effective use, in the short to medium terms, of existing technology and environmental data in order to create a greater public and government awareness of the benefits of remote-sensing technology and its use in the management of natural resources and the environment; and (b) ways of ensuring, in the longer term, through research, education and training that scientists and technologists of recipient countries acquire the skills and knowledge necessary to support and stimulate academic and individual research in remote-sensing technology and satellite meteorology so that they can undertake effective environmental management programmes. In their personal capacities, the participants made a number of observations and recommendations.

The Meeting noted that:

(a) Since the early 1970s, there had been considerable development of the technology of remote sensing. That has included developments in the variety of sensors and spatial resolutions available to the user and a substantial reduction in the cost and size of computer-operated image analysis systems needed to process the data provided by enhanced spaceborne remote-sensing systems. That has led to increasing operational use of remote-sensing data;

READEX FICHE

(b) The benefits resulting from the use of remotely sensed data in monitoring, mapping and managing the natural resources and environment of a country were well documented and had led to the extensive use of such data by developed countries and, to a lesser extent, by some developing countries. The science and application of remotely sensed data constituted a major input into the wider development of spatial information systems, which include the traditional areas of base and thematic mapping and the newer areas of land and geographic information systems;

(c) Many developing countries, however, were currently making little or no use of those data sources, owing to a range of economic, educational or administrative problems, resulting in a significant loss in their ability to manage and develop their resources and to increase the standard of living of their people;

(d) To bring the greatest benefits to humanity as a whole and particularly to the developing countries, there should be increasing efforts in education at all levels in order to create a public awareness of the value of that science and technology for the rational management of natural resources;

(e) Remote sensing for meteorological applications had virtually been operational since the late 1960s. Today, many countries were acquiring data from meteorological satellites for weather forecasting and for drought and flood early warning systems;

(f) In the field of the environment and the management of natural resources such as forests, water and soils, the use of remote sensing had proved essential in the developed countries. Because of the poor state of mapping of such resources in most developing countries, the need to use remote sensing for the improved management of these resources was not only urgent, but it was also the most cost-effective approach to that management issue. Already, numerous environmental and natural resource management projects in many developing countries were being managed by consultants from the industrialized countries on a technical assistance basis. There was a need for a more lasting solution through the training of indigenous scientific and technical manpower in remote sensing in order to provide for the short- and long-term management of natural resources and the environment at the local level.

B. Effective use of existing remote-sensing technology and environmental data

1. Development of focal structures

10. The Meeting recommended that Governments should give urgent consideration to the establishment and support of a national remote-sensing co-ordinating committee and a national remote-sensing centre and should support the formation, where appropriate, of a national association of remote-sensing professionals.

11. As a matter of urgency, each country should establish such a national co-ordinating committee in order to facilitate and oversee the introduction of remote-sensing technology, which were prerequisites for the development of a

national remote-sensing centre. The membership of the committee should, at least, consist of representatives of:

(a) Policy-making bodies that control the sources of funds and that can reallocate funds to user agencies;

(b) User agencies or potential user agencies including governmental, private and educational institutions;

(c) Representatives of government departments or ministries that were not involved in the applications directly and could make important judgements.

12. The role of such a co-ordinating committee should include the following activities:

(a) Facilitating and supporting the development and establishment of a national remote-sensing centre;

(b) Facilitating the formulation of a national policy supported by a master plan for the phased introduction of remote-sensing technology;

(c) Promoting the use of remote-sensing technology;

(d) Disseminating information on remote-sensing technology;

(e) Preparing a critical analysis of the benefits of remote-sensing technology for the physical and social environment of the country;

(f) Developing adequate and appropriate co-ordination and linkages between agencies, both internal and external;

(g) Facilitating appropriate education and training in remote sensing;

(h) Preparing an inventory of the country's skilled human resources and existing applications of remote sensing, if any;

(i) Assisting in the development of demonstration projects, where appropriate;

(j) Seeking funding sources, both internally and externally, and co-ordinating the appropriate use of such funds;

(k) Supporting existing agencies or groups that had demonstrated their ability in the use of remote-sensing technology.

13. The national remote-sensing centre should implement the recommendations of the co-ordinating committee. The structure and resources given to such a national centre would depend upon the user environment in the country. The primary role of the centre should be the development and support of remote-sensing technology at the national level.

14. Support for the development of a national association of remote-sensing professionals was also seen to have advantages for the introduction of remote-sensing technology, but it would depend upon a critical mass of such professionals being available within the country.

2. National and regional inventories

15. The Meeting recommended that Governments, as a matter of critical and immediate importance, undertake an inventory of existing remote-sensing resources in their countries and that the inventory be complemented by regional inventories promoted through the United Nations.

16. To develop a master plan for the introduction of remote-sensing technology successfully, it was seen as critical that each country undertake an evaluation of its existing remote-sensing resourses. Such an inventory should include the following:

(a) A listing of existing agencies currently involved in remote-sensing research and applications including government, private, academic and professional associations;

(b) The numbers and educational backgrounds of existing and needed human resources;

(c) A complete listing of existing and functional analog and digital remote-sensing equipment;

(d) A complete listing of existing data and maps;

(e) An identification of potential users of remote-sensing technology, including a list of the names and addresses of contact persons in all current and potential user agencies;

(f) The experience acquired through past and present applications and research in the area of remote sensing;

(g) Past and present sources of aid funds in support of remote-sensing training, education, research and applications;

(h) Existing institutional structures and linkages that might be supporting or negating the introduction and application of remote-sensing technology.

17. The other United Nations regional commissions should support and promote the development of regional inventories of users and applications in the same manner as had been developed by the Regional Remote Sensing Programme of the Economic and Social Commission for Asia and the Pacific (ESCAP).

3. Government and public awareness

18. The Meeting recommended that Governments be encouraged to support public awareness programmes through national committees or centres or other interested groups or associations.

19. The applications of remote-sensing technology would be optimized only through an awareness, at all levels of the Government and the public, of existing remote-sensing technology programmes and of the benefits that could be derived from them. The national co-ordinating committee, in co-operation with the centre, should develop that awareness through education, training, public relations and the demonstration of current remote-sensing technology programmes and products. Awareness could be developed through some or all of the following:

(a) Publishing and distributing nationally a remote-sensing newsletter;

(b) Developing and utilizing contacts with media representatives;

(c) Organizing awareness workshops for appropriate government, private and education decision makers as well as professionals and technical support persons;

(d) Developing audio-visual and demonstration materials for distribution to institutions and agencies, the media, universities and primary and secondary schools. The provision of such materials to schools would have a positive impact on the teaching of and interest in mathematics and the sciences;

(e) Establishing low-cost receiving facilities for meteorological satellite data to illustrate and demonstrate the benefits of remote sensing to government employees, students and the public at large;

(f) Establishing a comprehensive and appropriate educational programme to introduce remote-sensing technology into education curricula;

(g) Using mobile display units that could be exhibited in schools and science museums and at scientific fairs.

4. Data acquisition, processing, interpretation and archiving facilities

20. The Meeting recommended that Governments provide processing, interpretation and archiving facilities and urgently develop mechanisms for data collection either through the establishment of receiving facilities or appropriate external agreements and that the United Nations, through its good offices, encourage the widest access to and distribution of remotely sensed data at the lowest possible cost to developing countries.

21. It was critical to the development of indigenous capability in the use of remote-sensing technology that countries have access to spaceborne remotely sensed data and processing, interpretation and archiving facilities. That could be

achieved through the establishment of a receiving facility and a national centre with appropriate processing, interpretation and archiving facilities. However, it was recognized that, because of economic and other constraints such a receiving facility might best be established on a regional basis.

5. Overcoming obstacles to the implementation of recommendations

22. A range of obstacles and bottle-necks were seen as obstructing the implementation of remote-sensing programmes in developing countries. They are listed below, together with possible solutions. It should be recognized that the following did not constitute a comprehensive list but should be supplemented on the basis of national experience.

(a) Lack of availability of in-country representatives of hardware and software supplies. Possible solutions included:

(i) Greater use of technology trade fairs;

(ii) Establishment of a central agency to provide comprehensive information and advice on technological trends;

(iii) Promotion of workshops on technology change;

(iv) Wider distribution of reports by the concerned agencies and departments of the United Nations on remote-sensing technology, and updating of same;

(v) Use of public domain software (such software could be accessed free of charge through computer networks);

(vi) Attracting the attention of major companies (whose operations, only in part, cover remote sensing) to the need to provide remote-sensing advice at general technological trade fairs;

(vii) Publication, at regular intervals, of a special volume on current remote-sensing hardware and software, in co-operation with such entities as Commission VI of the International Society of Photogrammetry and Remote Sensing (ISPRS), through the ISPRS Journal of Photogrammetric Engineering and Remote Sensing, or the International Journal on Remote Sensing;

(b) Problem of availability of spare parts for image processing systems. Solutions included:

(i) Greater standardization of products;

(ii) The development of personal computer (PC)-based image-processing systems should alleviate the problem since the computers had wide applications for word-processing and other commercial and administrative functions;

(c) Low numbers of data users. Solutions included:

(i) Encouraging greater awareness of the potential benefits of the technology;

(ii) Creating interest in other potential user groups such as industrial, medical and non-destructive testing applications;

(iii) Increasing education in universities;

(d) Fear that technology would crea[te] unemployment. Solutions included increasing the awareness of Governments th[at] (i) increased employment of science and technology graduates would result from the use of remote sensing; and (ii) greater efficiencies in the resource sector would create increased service industries;

(e) Need for low-cost rugged indigenous equipment. Solutions included greater collaboration between developing countries in the production of such equipment;

(f) Policy problems restricting access to aerial photographs and maps. Solutions included the fact that Governments should be urged to make aerial photographs and maps available to their own users as their restriction unduly impeded civilian use of those important data in national development efforts.

C. Skills and knowledge necessary to support and stimulate research in remote-sensing technology

1. Indigenous technological capability

23. There should be a concerted effort to incorporate the principles of remote-sensing science and technology in appropriate basic science courses.

24. Collaboration between educational establishments in developed and developing countries should provide education and training locally in the developing countries as part of bilateral and multilateral programmes. National and international aid agencies should be approached to sponsor that form of indigenous capability development.

25. Special efforts should be made to negotiate for technical assistance to stimulate more widespread training and education of scientists and educators in the relevant aspects of space sciences at all levels of society in the developing countries, and the provision of training and education in remote-sensing science and technology at the undergraduate and postgraduate levels at the universities in those countries.

26. Existing or new institutes should increase training and education in remote-sensing science and technology in the developing countries. To meet the associated financial needs, arrangements should be made to find bilateral and multilateral funding sources.

2. Remote-sensing curricula within the educational system

27. There was a need to develop teaching modules on remote sensing and its applications at the university level. Those modules should involve a wide range of data types and samples of imagery adapted to local conditions.

28. There was also a need to organize an education programme that would include subprogrammes at the primary, secondary and higher education levels, which could be in the form of modules. At the lower levels, such subprogrammes should focus on conventional photography concepts and elements of remote sensing which could be introduced at the secondary school level.

3. Non-formal education

29. A representative listing of factors that were obstacles to the transfer and application of remote-sensing technology for development included insufficient number of experienced personnel; economic constraints; insufficient inter-institutional co-operation and networking; insufficient knowlege regarding the value of remote-sensing technology in solving national and regional problems among government decision makers; hardware and software problems.

30. Member States were strongly urged to take advantage of the various workshops that were being organized by the departments and agencies of the United Nations system at the national and regional levels for decision and policy makers with the aim of developing awareness of the potential of remote-sensing technology in the management and decision-making processes particularly on issues that were of social and economic importance to national development.

31. Similarly, Member States should take advantage of the seminars and workshops that were being organized at each regional remote-sensing centre by different entities. Initial lectures and discussions on those activities were often related to the major obstacles that end users must face and overcome to implement remote-sensing projects. They would serve as a background to the more important segment of the work that would involve discussions of strategies that could be developed to move beyond the obstacles to successful project implementation. That could be implemented as part of a programme on the development of indigenous capability in remote-sensing technology through the provision of relevant education for educators.

32. Additional workshops, seminars and "hands-on" exercises should provide education and training concerning new and advanced remote-sensing technologies and encourage, where possible, research in those areas, particularly relating to recent developments in hardware and software.

4. Acquisition of data

33. Mechanisms should be sought through which satellite and ground station operators would commit to provide annually, through appropriate channels, a basic set of remotely sensed data, at no charge, covering selected regions, thus encouraging developing countries in their use of remote-sensing data for resource management.

34. Compatibility should be stressed for ground segment elements of remote-sensing systems, particularly data down-link subsystems (such as band widths, frequencies and modulations).

35. Remote-sensing system operators and suppliers should strive for further standardization of data formats and required ground segment hardware.

36. System planners should strive to assure continuity, compatibility and complementarity of remote-sensing satellite programmes.

37. Access for users of remote-sensing data to all types of data products should be streamlined.

5. Applications and education

38. Education programmes on the use of remote-sensing techniques should be designed to include the key (natural) resources characteristic of each local/national/regional situation. For example, on the subject of land use, the curricula should include the elements necessary for the economic assessment of observed land use, economic analysis of alternative land use, and evaluation of the role of remote-sensing techniques in selecting acceptable/sustainable natural resource and land-use management strategies.

39. In parallel with curriculum development within the educational system, a management principle should be developed with appropriate extension programmes organized through relevant natural resource departments with the cognizance and support of the regional remote-sensing centres. Active application programmes could be developed for students at each educational level from primary through university.

40. The United Nations, in collaboration with other multilateral and bilateral funding agencies, should endeavour to provide urgent assistance to developing countries in remote-sensing science and technology for the monitoring and management of their environment and its natural resources. In the long term, every effort should be made to assist those countries to acquire the appropriate education and training facilities in remote-sensing science and technology to be self-reliant in those vital areas of resource management.

6. Centres of excellence

41. An indispensable aspect of any educational programme was the availability of teachers. All the educational programmes identified above would need a variety of teachers who were not available today in most developing countries. Thus, it would be necessary for the United Nations to spearhead a major effort to achieve that goal.

7. Communication, networking and information exchange

42. A communication network should be established to link appropriate centres and agencies within and between developing countries for data-base inventory and remote-sensing technological exchange.

43. Collaboration should be encouraged among major suppliers of remote-sensing data so tnat they would provide centralized services and materials suitable for "general education" through the media.

44. An information network and/or electronic bulletin board should be established between source countries and developing countries; the information shared would include such details as current hardware and software standards and data-base points of contact.

II. SUMMARY OF PRESENTATIONS

A. Attitudes and policies

45. The relevance of space science and technology to the social and economic development of a country was highlighted through specific applications of space science and technology. They included (a) the use of communication satellites for broadcasting educational programmes to remote areas in a country; (b) the use of Earth observation satellites to conduct national resources surveys and to monitor resource exploitation; and (c) the use of meteorological satellites to minimize the economic and social impact of natural disasters such as droughts, cyclones and floods.

46. In the field of remote sensing it was noted that (a) several developing countries had started acquiring space systems, including remote-sensing systems; (b) many developing countries were participating in the applications of remote sensing; (c) some developing countries had plans to develop their own integrated indigenous space programmes; and (d) a few developing countries had already proven themselves capable of developing their own integrated indigenous space programs.

47. There was a growing awareness in many of those countries that they should be concerned not only with what a given space technology could do, but also with how and why it worked the way it did.

48. Reference was made to the new research and applications fields which were evolving, including the production of goods in space (space manufacturing). In

that context, the developing countries could not afford not to participate in the research and technology efforts; it was stressed that their involvement could be accomplished through education and training of their own personnel. An overconcentration, on the part of developing countries, on practical, short-term projects to the detriment of long-term research capabilities was observed.

49. The need for the development of remote-sensing skills and knowledge at the local level derived from its importance to economic and social development. Since the beginning of the space age, 32 years before, remote-sensing technology and its applications had steadily become more important to development, initially in the technologically advanced countries and more recently in many of the developing countries as well.

B. Experiences gained and infrastructure needed

50. The development of educational programmes and materials in remote-sensing applications at the national, regional and international levels was presented by the International Institute for Aerospace Survey and Earth Sciences of the Netherlands. In developing educational programmes and materials in remote sensing, it would be necessary to identify the intended recipients, which should include the following: (a) qualified professionals in the Earth observation sciences; (b) cartographers; and (c) planners and decision makers. Educational modules could be developed for each of those broad categories of personnel taking into account (a) target groups; (b) subject-matter; (c) entry level; (d) methodologies; (e) availability; and (f) constraints and obstacles.

51. Access to reference material was a necessary and significant step for any country intending to develop remote-sensing skills and knowledge. Today, the possibility of operating bibliographic referral centres in space science and technology at moderate cost was a direct consequence of recent technological advances - the availability of microcomputers had made it attainable. Their power would increase while costs would remain stable or decrease. One of the challenges of today was how to organize the ever-increasing influx of information and data for ease of use and for the benefit of future generations of users.

52. Projects involving the use of data from satellites in Earth orbit were particularly well suited for international co-operation. Granted that there was no substitute in the long term for the development of sound science and technology, the developing countries were faced with the necessity of active participation in space, not only for shortening the technological gap between them and the developed countries, but also for the utilization of modern techniques in the evaluation of their own natural resources. A major goal could be achieved in furthering national space technological expertise if such schemes could be addressed through regional/international co-operative programmes.

C. Education programmes and teaching aids for teachers

53. The integration of space science and technology and particularly remote sensing into development programmes depended to a large extent on the perception of the country's scientific and economic policy makers. That perspective in turn depended on the level of understanding of the subject by the technical and administrative cadres of the country. Thus, it was important to promote general awareness of the potential benefits as well as to provide specialized education and training in the disciplines involved. With that in mind, the participants were provided with an overview of the benefits of space activities and of education, training and research opportunities that could assist in realizing those benefits.

54. Basic space sciences such as meteorology, geophysics, astronomy and astrophysics advanced the frontiers of knowledge of the Earth and the universe as a whole. Basic research, however, had also had a direct impact on many areas that touched upon everyday life. For instance, the effect of solar radiation on the Earth's atmosphere was directly related to weather patterns. In addition, studies of the mesosphere and its effects on the upper troposphere were necessary for mid-range weather forecasting.

55. In addition to existing national professional and academic opportunities for training personnel in the areas of space science and technology, countries might take advantage of a number of training opportunities abroad. In that connection, participants were provided with the information contained in the publication "Education, Training, Research and Fellowship Opportunities in Space Science and Technology and its Applications: A Directory" (A/AC.105/432). The Directory contained global information on institutions with programmes in research, education and training in basic space sciences, remote sensing, satellite meteorology and satellite communications. It provided a description of the principal functions of the institutions, summaries of their courses and research programmes, the duration and frequency at which such programmes were offered and the cost of tuition, education materials and living expenses. It also contained information on scholarships, fellowships and other forms of financial aid that might be available at a given institution, and it identified institutions that were interested in collaborating with other institutions on specific scientific topics and in specific geographical areas.

56. In order to promote the integration of space science and technology into its education and development programmes, a country must define a policy that provided the framework within which the various elements would contribute to the educational goals. For example, the National Aeronautics and Space Administration (NASA) of the United States had taken various steps to expand students' interests in science, mathematics and technology. In anticipation of Space Station "Freedom", the projected series of planetary missions and other aerospace developments, students were being encouraged to prepare themselves for key roles in the nation's future work force. NASA programmes also integrated the knowledge derived from aerospace research and development into the educational system at all levels - elementary through university.

57. The programme for a visiting educator/scientist within a European context, developed by the European Association of Remote-Sensing Laboratories and by the

ERASMUS Programme of the Commission of the European Communities had been very valuable and had contributed greatly to the expansion of education and training opportunities in remote sensing. However, its use was restricted to European countries, and there were only a few applications of remote sensing that were relevant for countries outside Europe. It was emphasized that having alternate plans to permit exchange of data on a world-wide basis would be beneficial.

58. It was noted that space science and technology not only were subjects for study, but also could provide educational materials, for both space-related and other disciplines. Communication satellites could be used to distribute educational and cultural programmes throughout a country or from one country to another. Foreign television programmes could be effective tools for foreign language teaching. Earth observation satellites provided images of the Earth that could be used for lessons in geography and the earth sciences. The planning and management systems that had been developed for space programmes provided excellent case studies for training in general planning and management. Furthermore, the history of astronomy and other space sciences formed an important part of the history of civilization, in part because the movements of the Earth, the Moon, the Sun, the planets and the stars provided relatively clear and simple illustrations of the basic laws of physics.

D. University programme for research and application professionals

59. Direct reception of environmental satellite data was available on a global basis. Several aspects of direct readout technology made it suitable to the development of low-cost institutional remote-sensing programmes. Of particular interest to potential programme developers were the current applications of directly received data at the university level, and the implications of recent reductions in the cost of data-receiving equipment. The United States National Oceanic and Atmospheric Administration's National Environmental Satellite, Data, and Information Service (NOAA/NESDIS) made a presentation about technical support that was available to assist programme development. NOAA/NESDIS technical memoranda and reports were formulated to assist in station development and data processing, and might also be incorporated into the curricula. The NOAA DRUSER Electronic Bulletin Board and the international accessibility of the Electronic Bulletin Board provided operational assistance to direct readout stations.

60. Digital image analysis was being taught in many educational institutions. Mainframe computers were suited for handling large classes, but increasingly, educators were turning to microcomputer-based systems for teaching digital image analysis. There was considerable literature on available hardware and software, but relatively few educators had addressed the pedagogic issues. It was recommended that the following activities could aid remote-sensing educators:

(a) Identifying the main concepts and ideas that should be taught in courses on digital image analysis at a variety of educational levels;

(b) Developing model curricula and educational materials for courses in digital image analysis. (It should be noted that a similar activity in the field

of geographic information systems was currently being undertaken by the new National Center for Geographic Information and Analysis in the United States.);

(c) Collecting and making available information on equipment and software packages for microcomputer-based digital image analysis;

(d) Developing teaching modules that were appropriate for or could be adapted to different geographical areas or applications. They should include a wide range of data types and examples of imagery.

61. Tropical deforestation was one of the most critical problems confronting mankind. The majority of such forests were found in developing and newly industrialized countries. Tropical forests comprised only 7 to 8 per cent of the Earth's land surface but almost half of the global wood stock and at least two fifths of the Earth's species. Tropical forests played a major role in the maintenance of the precarious carbon dioxide balance of the Earth's atmosphere. Destruction of that global resource was taking place at an alarming rate. At the current estimated rates of deforestation, by the year 2050 the forests would disappear, except for small areas preserved as parks, in contrast to temperate forests, which were expected to decline less rapidly thanks to reforestation. The effects of tropical deforestation might include a detrimental impact on vital global processes as well as on economic and social development programmes at the national level. In addition, tropical deforestation could be linked to increased human suffering, in terms of loss of lives, livelihood and shelter.

62. Observation of tropical deforestation based on optical systems was limited by optical visibility. Tropical forests were frequently occluded by cloud, fog and mist. Radar frequencies could penetrate cloud so that tropical forests were observable from radar satellites. While there was a forestry radar data base, it basically did not include tropical data. More importantly, there was no co-ordinated plan to utilize existing and prospective radar remote-sensing systems to respond to that problem. There was also a lack of linkages between the leading radar operating nations and the developing countries whose future might depend on addressing the deforestation issue.

63. Critical milestones scheduled to occur in the next few years made it appropriate for a major programme to be considered. The most important experimental radar mission was SIR-C (1992). Future operational C-Band radar satellite systems included ERS-1 (to be launched in 1991) and RADARSAT (to be launched in 1994). Ground stations and associated facilities to be established for the reception and processing of satellite SAR data within the developing regions were under consideration.

64. Users of remote-sensing data required more customized products supported by appropriate systems and training if the potential of remote-sensing technology was to be realized. Other outstanding issues included access to data, data acquisition and continuity of Earth resources satellite programmes. Global agreements on those topics were urgently needed. Also urgent are training and project support, suitable data-processing systems and agreements on compatibility between systems in order to permit the exchange of data for use in resource assessment. Most of the present problems could be resolved through co-ordinated action by the donor countries, operators of Earth resources satellite systems and the beneficiaries.

Annex

PROGRAMME OF THE MEETING

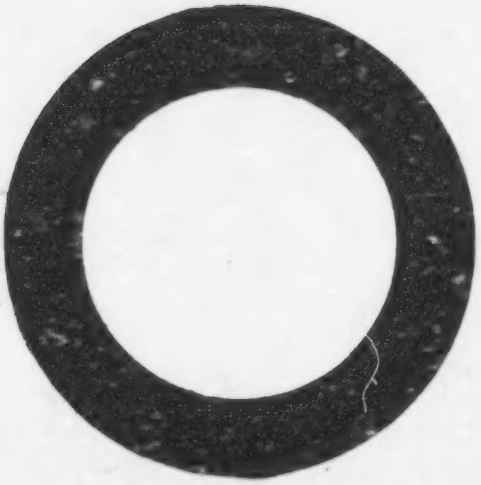
Date	Time	Subject	Speaker
Monday 26 June	9-9.30 a.m.	Opening ceremony	
		Welcome address on behalf of the University of Dundee	M. J. Hamlin
		Welcome address on behalf of the United Nations	A. A. Abiodun
		Welcome address on behalf of the Government of the United Kingdom	P. H. D. Wetton
	9.30-10.15 a.m.	Keynote address: the integration of remote sensing into national development programmes	N. Press (United Kingdom)
		Session A: Attitudes and policies	
		Chairman: M. El-Raey (Egypt)	
	10.30-11.15 a.m.	Development of indigenous scientific and technological capabilities: bottlenecks and limitations and efforts required in the developing countries	P. Sudarsan (India)
	11.15 a.m.-12 noon	The need for education in space science and technology: a project proposal	A. A. Abiodun (United Nations)
		Session B: Experiences gained and infrastructure needed	
		Chairman: Mohamed Ahmed Tarabzouni (Saudi Arabia)	
	1.45-2.30 p.m.	Training programmes in Earth resources surveys including follow-up monitoring exercises in participating countries	J. J. Nossin (Netherlands)
	2.30-3.15 p.m.	Transfer of skills and knowledge: experience of UNESCO through its International Programme for the Development of Communication	G. Dupont-Henius (UNESCO)

/...

Date	Time	Subject	Speaker
Monday 26 June	3.30-4.15 p.m.	Bibliographic reference centres in space science and technology: operational aspects of referral/ retrieval	G. Proca (ESA)
	4.15-5 p.m.	Regional co-operation projects/ programmes as a means to enhance scientific and technological expertise	R. Alvarez Univ. of Mexico (Mexico)
		Session C: Education programmes and teaching aids for teachers	
		Chairman: O. B. Dick (Norway)	
Tuesday 27 June	9-9.45 a.m.	Outreach programmes in space science and technology for teachers at the primary and secondary levels	F. Owens NASA (United States)
	9.45-10.30 a.m.	Establishing a visiting educator/ scientist programme: opportunities and bottlenecks	A. P. Cracknell Univ. of Dundee (United Kingdom)
	10.45-11.30 a.m.	The role of joint venture production as a means of skill transfer and technological updating	N. Press (United Kingdom)
	11.30 a.m.- 12.15 p.m.	Means of ensuring that educational curricula at whatever level keep pace with (i) technological development elsewhere and (ii) user needs	J. J. Nossin (Netherlands)
		Session D: University programme for research and application professionals	
		Chairman: A. P. Cracknell (United Kingdom)	
	1.45-2.30 p.m.	Direct readout in university remote-sensing programme development: implications and implementation	T. D. Potts NOAA/NESDIS (United States)
	2.30-3.15 p.m.	Developing university-level curricula and research projects	H. S. Gurm Punjabi Univ. (India)

Date	Time	Subject	Speaker
Tuesday 27 June	3.30-4.15 p.m.	The development of skills and knowledge in using image analysis packages on microcomputer systems	P. Howarth Univ. of Water (Canada)
	4.15-5 p.m.	The observation of tropical forest by C-band radars: Proposed 10-year project	R. K. Raney (Canada)
		Session E: A critique	
		Chairman: P. Sudarsan (India)	
Wednesday 28 June	9-9.45 a.m.	Recent experience in defining remote-sensing needs and effective implementation plans for Africa	W. Laing (United Kingdom)
	9.45-10.30 a.m.	The scope for developing simpler/ cheaper types of equipment which can be widely adopted	J. I. Thomas (United Kingdom)
	10.45-11.30 a.m.	A critical appraisal of the experience of France in remote-sensing user assistance, world wide	P.-H. Pisani (France)
	11.30 a.m.-12.15 p.m.	Remote sensing for development: Considering the user: ways of making suppliers more sensitive to recipient country needs both as regards design and back-up	A. Falconer (Kenya)
	1.45-5 p.m.	Working group sessions	
		Working Group A:	
		Chairman: Bruce Forster (Australia) Rapporteurs: M. Ishaq Mirza (Pakistan) Ibrahim El-Kassas (Qatar)	
		Ways of making more effective use, in the short to medium term, of existing technology and environmental data in order to create a greater public and government awareness of the benefits of remote-sensing technology and its use in the management of the environment	

Date	Time	Subject	Speaker
Wednesday 28 June		Working Group B: Chairman: H. S. Gurm (India) Rapporteurs: Maurice Arthur Keech (United Kingdom) Richard S. Odingo (Kenya) Ways of ensuring, in the longer term, through research, education and training that scientists and technologists of recipient countries acquire the skills and knowledge necessary to support and stimulate academic and individual research in remote-sensing technology and satellite meteorology so that they could undertake the necessary environmental management programmes	
Thursday 29 June	8 a.m.-12 noon	Working group A (continued) Working group B (continued)	
Friday 30 June	8 a.m.-10.30 a.m.	Working group A (continued) Working group B (continued)	
	1-3 p.m.	Conclusions and observations of the Meeting Chairman: A. A. Abiodun (United Nations) Rapporteurs: C. Specter (United States) P. A. Vass (United Kingdom)	
	3-3.30 p.m.	Closing ceremony	



UNITED NATIONS

A

General Assembly

Distr.
GENERAL

A/AC.105/439
9 January 1990

ORIGINAL: ENGLISH

COMMITTEE ON THE PEACEFUL USES OF
OUTER SPACE

REPORT ON THE UNITED NATIONS/INDIAN OCEAN MARINE AFFAIRS CO-OPERATION CONFERENCE WORKSHOP ON OCEANOGRAPHIC/MARINE SPACE INFORMATION SYSTEMS, CO-SPONSORED AND HOSTED BY THE GOVERNMENT OF PAKISTAN

(Karachi, 2-6 July 1989)

CONTENTS

	Paragraphs	Page
INTRODUCTION	1 - 11	3
A. Background and objective	1 - 4	3
B. Organization and programme of the Workshop	5 - 11	3
I. RECOMMENDATIONS AND PROPOSALS	12 - 35	4
A. Data availability and exchange	12 - 16	4
B. Scientific co-operation mechanisms	17 - 27	5
C. Archiving and retrieval of space data	28 - 35	6
II. SUMMARY OF PRESENTATIONS	36 - 59	8

Annexes

I. Programme of the Workshop	15
II. Marine interests and satellite data requirements	19

CONTENTS (continued)

		Page
III.	IOMAC programme of integrated marine space application projects	20
IV.	A pilot project for the Indian Ocean region (IOMAC/NOAA)	22
V.	Some possible IOMAC MSAP programmes	24

INTRODUCTION

A. Background and objective

1. The United Nations/Indian Ocean Marine Affairs Co-operation Conference (IOMAC) Workshop on Oceanographic/Marine Space Information Systems, co-sponsored by the Government of Pakistan and hosted by the Pakistan Space and Upper Atmosphere Research Commission (SUPARCO) at Karachi from 2 to 6 July 1989, was one of the activities of the United Nations Programme on Space Applications for 1989.

2. The Workshop was organized in accordance with the recommendations of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE 82) and the relevant resolutions of the General Assembly, in particular resolution 43/56 of 6 December 1988, in which the Assembly reaffirmed the importance of the establishment and strengthening of regional mechanisms of co-operation as well as the importance of the role of the United Nations, through its Space Applications Programme, in the promotion of such co-operation. The Workshop also responded to the request of IOMAC for assistance in identifying areas of co-operation in applications of space technology to oceanographic and marine affairs and in determining practical steps to achieve such co-operation for the benefit of countries in the Indian Ocean region.

3. The objective of the Workshop was to analyse the requirements of space information systems for the assessment, evaluation and management of marine and coastal resources as well as in monitoring the environment of the Indian Ocean region. It was organized to provide participants with basic information on space information systems and the application of data available from such systems, including the reception, processing and archiving of vast amounts of data and information. The Workshop also identified further co-operative mechanisms, programmes and projects that could be developed for the benefit of Member States in the Indian Ocean region.

4. The present report, which covers the background, objective, organization and recommendations of the Workshop, has been prepared for the Committee on the Peaceful Uses of Outer Space (COPUOS) and its Scientific and Technical Sub-Committee.

B. Organization and programme of the Workshop

5. Invitations to nominate participants for the Workshop were sent by the United Nations and IOMAC Member States both within and outside the Indian Ocean region as well as to international organizations. Seventy (70) experts from the following 21 Member States and 7 international and regional organizations participated in the workshop: Bahrain, Bangladesh, Comoros, Ethiopia, Indonesia, Iran (Islamic Republic of), Iraq, Kenya, Kuwait, Madagascar, Malaysia, Oman, Pakistan, Qatar, Somalia, Sri Lanka, Tanzania, Thailand, Uganda, Union of Soviet Socialist Republics, United States of America, United Nations Educational, Scientific and Cultural Organization (UNESCO), United Nations Environment Programme (UNEP), Food

and Agriculture Organization of the United Nations (FAO), European Space Agency (ESA), International Maritime Satellite Organization (INMARSAT) and the United Nations (Outer Space Affairs Division).

6. Funds allocated by the United Nations, UNESCO, and IOMAC (through funding by the United Nations Development Programme (UNDP)) for the Workshop were used to cover the cost of international air travel and pocket-money for 27 participants. The Government of Pakistan provided the conference facilities, room and board for 27 participants and local transportation for the duration of the Workshop.

7. Opening addresses were delivered by the Hon. Jahangir Badar, Minister for Science and Technology of Pakistan, on behalf of the Government of Pakistan; Mr. Shafi Ahmad, Chairman of SUPARCO; Mr. Hiran W. Jayawardene, Secretary-General of IOMAC; and Mr. Nandasiri Jasentuliyana, Chief, Outer Space Affairs Division of the United Nations.

8. The programme of the Workshop is shown in annex I to the present report. The Workshop was conducted by means of a series of plenary and working group sessions.

9. The Workshop recognized the vital importance of space activities to the development process of the individual countries and of the region as a whole, and noted that the execution of specific projects using oceanographic/marine space information systems has proved to be a useful tool for the development of countries such as those of the Indian Ocean region.

10. It also noted the comparative benefits of carrying out bilateral and multilateral programmes between countries of the region with similar needs and problems, and it recognized the need for training at all levels and in all sectors and the benefits of increasing the flow of information among the various countries of the region and between those countries and international regional bodies.

11. It welcomed the role of the Indian Ocean Marine Affairs Co-operation Conference in initiating, the United Nations in organizing and the Government of Pakistan in hosting the Workshop. It recognized the importance of continuing the process initiated at the Workshop and it subsequently adopted the following recommendations and proposals.

I. RECOMMENDATIONS AND PROPOSALS

A. Data availability and exchange

12. All Governments in the Indian Ocean region should facilitate the acquisition of satellite data relevant to the region and should establish and maintain national facilities capable of receiving, analysing and archiving such data so that they could be used for the maximum benefit of the region.

13. Since the current mechanisms for the exchange of data have not been effective, the meeting strongly supports the recommendations contained in paragraphs 16 and 26 of the report on the United Nations Regional Meeting of Experts on Space Technology

Applications in the Indian Ocean Region, held at Colombo from 15 to 19 September 1986 (A/AC.105/374). In order to address the related issues properly, the matter should be taken up at the forthcoming IOMAC Standing Committee meetings with a view to incorporating technical-level participation in IOMAC focal points as indicated in the above-mentioned recommendations.

14. Because the countries of the region have different levels of capability in utilizing space technology, it was recommended that each country could enhance its own capabilities by taking advantage of the different training opportunities that are available within the United Nations system annually. Existing infrastructure for education and training in space technology within the region should be enhanced and new ones developed as necessary. Assistance in this connection from national, regional and international organizations with advanced capabilities/facilities in space technology should be requested whenever required.

15. Under the prevailing conditions, the many benefits which could be derived from the use of space technology are not likely to be fully realized by developing nations; thus nations with advanced space programmes should provide data and imagery to the developing nations, particularly through technical assistance or at a minimal cost.

16. Annex II to the present report shows the types of data requirements for carrying out marine application programmes.

B. Scientific co-operation mechanisms

17. Guidelines for formulating various marine space applications projects (MSAP) of interest for IOMAC countries within a MSAP framework are given in annex III to the present report.

18. Regional pilot projects of direct relevance to IOMAC should be initiated in order to demonstrate the potential of space technology in solving some of the oceanographic and marine problems of interest to the countries in the region. One such regional project based on advanced very high resolution radiometer (AVHRR) data is outlined in annex IV to the present report.

19. In line with the recommendations of the United Nations Regional Meeting of Experts on Space Technology Applications in the Indian Ocean Region, held in Sri Lanka in 1986 (see A/AC.105/374), participants felt that IOMAC should immediately undertake to publish an "IOMAC Guide" on applications of space information for oceanographic and marine studies. This guide may serve the purpose of creating awareness among the scientific community of IOMAC countries and assist them to derive maximum benefit from the technology.

20. The need for the creation of a technical group within IOMAC, as recommended by the 1986 United Nations Regional Meeting of Experts on Space Technology Applications in the Indian Ocean Region, 1986 (A/AC.105/374, para. 10) was emphasized. In addition to its role of providing a technical base for IOMAC activities and plans, the committee should work out the budgetary requirements for

IOMAC projects and monitor the implementation of such projects, once they have been initiated. The IOMAC secretariat should endeavour to explore various likely sources for the necessary funding.

21. The IOMAC secretariat should undertake to prepare a list of institutions and of "contact persons" in institutions of those countries where a base exists for oceanographic/marine science activities. In countries where there is a lack of such facilities, contact persons may be identified through whom initiation of programmes in those countries could be undertaken in the future.

22. Once the relevant institution and contact persons have been identified, IOMAC should obtain information on existing data as well as on hardware and software facilities in those countries. IOMAC should complete its survey of capabilities in scientific fields and should disseminate the results of the survey among the relevant institutions of the region through the IOMAC Newsletter. IOMAC should also compile information on training opportunities within and outside the region so that scientists in the region might avail themselves of such training opportunities.

23. The IOMAC secretariat should prepare a list of oceanographic research vessels and major equipment available in the region, including information on their activities.

24. IOMAC should organize a "hands-on" workshop to be held at least once a year to provide training opportunities for scientists interested in applications of satellite technology for oceanographic and marine studies. It was suggested that the next workshop be held in an East African country.

25. The IOMAC secretariat should solicit financial support as well as services and expertise from the developed countries for any national projects initiated within an IOMAC country.

26. Participants also noted that international organizations such as INMARSAT and members of the United Nations system might be able to assist IOMAC countries in the initiation and implementation of space applications programmes (some examples are given in annex V to the present paper). The IOMAC secretariat should provide co-ordinating support to the interested countries of the region.

27. Progress review meetings should be held at least on a biennial basis to assess the progress attained and to remove the bottle-necks experienced in the implementation of the above recommendations. A special review meeting could be convened in 1992 during the International Space Year to review and assess the progress of MSAP.

C. Archiving and retrieval of space data

28. An Information System (IS) should be established, initially on an experimental basis, to facilitate the exchange of data and information between the countries of the Indian Ocean region. A similar programme already established within the Remote Sensing Programme of the Economic and Social Commission for Asia and the Pacific (ESCAP) at Bangkok could serve as a model.

29. The proposed system should contain information and data necessary to address the following issues:

(a) Basic scientific understanding of oceanographic/marine environmental processes (general and specific to the Indian Ocean region) such as bio-geochemical and physical interactions in the sea, or particular coastal ecosystems such as mangrove areas;

(b) Monitoring and management of marine resources;

(c) Particular needs of individual countries in the Indian Ocean region with respect to basic research and resource exploitation.

30. The potential users of IS can be subdivided into two main categories:

(a) Those countries where basic (or advanced) infrastructures already exist;

(b) Those countries that lack any kind of facilities.

31. On the basis of the above considerations, IS should satisfy the following requirements:

(a) Establishment of a regional reference system that describes the following data characteristics: type, source, availability, application potentials and information on user(s);

(b) Assistance in obtaining such data, through regional or national focal points;

(c) Provision of limited data-processing capabilities for some users who may lack adequate facilities;

(d) Provision of information and training on how to set up independent facilities capable of evolving into national components of a regional and subregional IS;

(e) Promotion of the establishment of suitable communication links for the transfer of information.

32. The system could include regional and local nodes (at the national or sub-national level). Regional nodes could be built around existing or planned data receiving stations, large computer centres or institutions (scientific or non-scientific) with expertise in remote-sensing applications. At the regional level, institutions such as SUPARCO (Pakistan), the Indian Space Research Organization (ISRO) and the National Remote Sensing Agency (NRSA) of India, the Asian Institute of Technology (AIT) of Thailand, the National Aeronautics and Space Institute (LAPAN) of Indonesia, the Space Research and Remote Sensing Organization (SPARRSO) of Bangladesh and the Regional Center for Remote Sensing in Kenya have the necessary capabilities. The local nodes could also serve as national stations which could provide services either to the local scientific community or to the environmental/resource management community.

33. The following are a number of recommendations on the proposed Information System:

(a) Establishment of an experimental regional centre (e.g., based in one of the existing data receiving stations, or, where adequate facilities are already in place, to be used as a regional node of the "distributed" IS);

(b) Initiation of activities in such an experimental regional centre for data collection, archiving, processing, retrieval and distribution;

(c) Identification of a small number of users, acting as provisional local nodes of the "distributed" IS, both within countries already having adequate facilities to play such a local role and within countries expressing an interest in initiating similar activities;

(d) Establishment of suitable communication links between the experimental regional centre and provisional local nodes, as well as between these nodes and the local end-user communities.

34. These initiatives should be carried out in the framework of a pilot programme conducted within the Indian Ocean region community. The programme could cover such activities as the use of available low-cost remote sensing data (e.g. AVHRR and coastal zone colour scanner (CZCS) historical time series) for various marine applications, or the collection of a high-resolution remote sensing data set covering the coastal areas for a one-time regional assessment of the mangrove ecosystems.

35. The successful implementation of the above recommendations may lead to the definition of a long-term programme for the development of an advanced IS capable of ensuring the full utilization of ocean remote sensing technology within the Indian Ocean region.

II. SUMMARY OF PRESENTATIONS

36. The application of space technology to oceanographic/marine activities has been developing steadily since the beginning of the space age and will undoubtedly continue to develop in the future. The new decade promises to be particularly rich in space maritime data and services. New satellite systems for oceanographic and marine resource surveys are now under development and the global maritime communication satellite network and search and rescue capabilities will advance, while maritime weather and storm warning services will continue to improve.

37. Remote sensing of the ocean is playing an increasingly important role in different areas of application. Satellite sensors make synoptic measurements of the sea surface temperature and colour, coastal processes, surface winds and waves and currents and tides over large areas of the ocean.

38. Modern developments in telecommunications and enhanced satellite capabilities for data collection, transmission and distribution will allow an increase in the

usefulness of meteorological and hydrological forecasts and warnings. The decade of the 1990s will witness significant changes in the applications of space acquired data to meteorology and hydrology as the technology for the acquisition, processing and analysis of satellite data continues to advance at a rapid pace.

39. Data acquisition by satellites and aircraft combined with ship measurements can provide synoptic observations of coastal and estuarine phenomena which vary rapidly in time and space. Coastal applications of remote sensing require a wide assortment of sensors, including the use of aerial cameras for beach erosion and vegetation mapping; multispectral scanners for wetland biomass and estuarine water property studies; thermal infrared scanners for mapping water surface temperatures and currents; microwave devices for salinity or wave measurements; and underwater cameras and acoustic systems for benthic observations. Meaningful observation of physical and biological processes in coastal and estuarine areas which vary rapidly in time and space (e.g., turbidity dynamics or phytoplankton bloom development) can be conducted by combining data remotely sensed by satellites and aircraft with ship/field acquired data.

40. Recent progress in optical modelling and instrument design is resulting in an effective survey of estuaries. Multispectral solid state video cameras and other sensors are being developed which can be flown on inexpensive small aircraft. Deployed in conjunction with satellites, these airborne sensors can observe tidal, seasonal and annual variations as well as spatial distributions of phytoplankton blooms, sediment plumes, estuarine fronts and circulation patterns. New hydrologic and optical data bases are being used to develop and refine practical models, such as the singly scattered irradiance model, to detect chlorophyll, suspended sediment and dissolved organic matter in turbid estuaries. Inexpensive microcomputers and user-friendly software are facilitating the analysis of Landsat multispectral scanner (MSS), Thematic Mapper (TM), Experimental Earth Observation System (SPOT), the AVHRR of the United States National Oceanic and Atmospheric Administration (NOAA), Nimbus/CZCS and other satellite data at small, local laboratories and research centres. These new techniques are being used to monitor the environmental quality of coastal waters and to compare the susceptibility to degradation (e.g., eutrophication) of estuaries, as required by various national and international programmes.

41. The European remote sensing programme has been established to provide an end-to-end all-weather Earth observation system in the 1990s; this would contribute not only to the monitoring of the planet's environment but also to the management of its resources. The ERS-1 mission is primarily dedicated to global oceanography, coastal, ice and regional land applications. Both the progress in technology and the need to observe the cloudy Earth by means of all-weather capability systems have dictated the ERS-1 payload, which is based on active microwave radars. ERS-1 is a forerunner of a series of microwave payload satellites that should provide operational services in the 1990s. Missions of this type would prepare the way for the polar platform and space station programmes.

42. Coral reefs, such as those found along the coastline of Sri Lanka, from near-shore fringing reefs to submerged reefs extending several kilometres offshore, are of considerable importance in the prevention of coastal erosion and enhancement

of the productivity of near-shore areas. These reefs serve as nursery and breeding grounds for many varieties of fish, crustaceans and other organisms that support coastal fisheries. The aesthetic beauty of such coral reefs is also an important tourist attraction. However, they are being destroyed through the removal of both live and dead corals for the manufacture of building lime or as specimens for the tourist trade, by destructive fishing practices and by land-based pollution and siltation. In order to conserve and manage these dwindling reef resources, a programme has been initiated in Sri Lanka by the National Aquatic Resources Agency. The coral reefs at Hikkaduwa on the southern coast of Sri Lanka have now been declared a marine sanctuary and have been demarcated by hydrographic surveys with position fixing using theodolites. Action has also been initiated to declare Unawatuna a multiple-use marine reserve area, and the boundaries of the area have been demarcated. Although hydrographic surveying is effective and has a high degree of accuracy, the work was expensive and time-consuming. Further extensions of the above reefs and new sites could be effectively demarcated by the use of high-resolution satellite imagery and airborne photography.

43. Mangrove forests are continually being threatened by anthropogenic extinction through such activities as clearing of mangroves for agriculture, salt evaporation ponds, poles and fuelwood. Mangroves play a key role in the preservation of coastal and offshore fish and shellfish stocks, and in preservation of the ecosystem by protecting the beaches from erosion by trapping silt and moving soil. In addition, mangroves provide wood products, medications, beeswax and honey for human consumption. Without preservation programmes and rational management of the mangrove forests and individual mangroves, they will soon disappear, leaving behind coastlines bare of normal vegetation and inshore and offshore waters which are unable to sustain exploitable and economically viable fisheries. There is a need for greater interaction between coastal land utilization planners and scientists in related fields so that planners can identify problems requiring scientific advice, while scientists should assess the potential impact of planning proposals and strategies. Thus, in order to minimize further damage to mangrove forests, there is a need to undertake national management plans for mangrove resources, based on sound basic data such as the distribution and status of the mangrove forests.

44. In order to apply space technology to its marine and fisheries operations, the Union of Soviet Socialist Republics is developing a space data system at the Main Space Data Research Centre of the All-Union Research Institute of Marine Fisheries and Oceanography (Glavcenter "Ocean") and four basin centres in the cities of Murmansk, Kaliningrad, Vladivostok and Kerch (USSR). The USSR Ministry of Fisheries conducts fishing operations over most of the world's oceans, and to a great extent utilizes space data for this purpose. The value of space data is dependent on its abililty to satisfy specific requirements of the user. Such requirements include the capability to process oceanographic information for large regions of the ocean, high speed delivery of the acquired data and high accuracy of measurements of a number of parameters which characterize the surface waters, including temperature, colour and wave conditions.

45. Satellites can provide important data for the study and monitoring of dynamic processes in the marine environment because of their synoptic and repetitive coverage. Conventional oceanographic data, similar to those collected from

isolated moorings or from individual cruises, have substantial spatial or temporal limitations. Synoptic data can be collected in this manner only at great expense. Spatial variability cannot be properly observed from a limited number of discrete stations or track lines, and cruises cannot often be repeated. Satellites, however, collect data at thousands of points over the water surface and adjacent land, thereby providing essentially continuous coverage. Sensors such as those on board the NOAA weather satellites provide coverage as often as two to four times a day, thereby permitting the modelling of dynamic estuarine and coastal processes. The synoptic coverage and availability of satellite data fill a void caused by the logistics and expense associated with conventional oceanographic measurements. However, satellites cannot provide information on the vertical structure of the water column; therefore, a combination of in situ measurements, remotely sensed data and modelling results are needed in the study of estuarine and oceanic processes.

46. Satellites have provided important environmental information on Chesapeake Bay in the United States and the adjacent shelf. In the presence of well-defined features, satellite data can be used to determine actual water circulation. Using such satellite data, one can obtain a synoptic view of sea surface temperatures, particularly during the day, calculate the reflectance caused by suspended solids and determine the presence and strength of phytoplankton blooms. Some characteristics of surface circulation can be inferred from the distribution of temperature and reflectance.

47. At present, satellites provid accurate sea surface temperature measurement to within 1° C. Reflectance values give an indication of the relative concentration of suspended solids; however, estimates of actual concentrations will depend on the ability to calibrate in situ data against remote measurements of reflectance. Similarly, the pigment index requires additional calibration in order to make it more widely applicable. However, the use of reflectance and the pigment index shows the potential ability of satellites in the study and monitoring of estuaries.

48. Successful applications of remote sensing to the solution of ocean and coastal problems require the following key elements: project planning; experimental design; mathematical/physical modelling; remote sensing data acquisition; field data collection; data processing and storage; information extraction; and data bank development for model calibration and verification. Some of these steps can be carried out at local laboratories, while others require regional collaboration if costs are to be minimized.

49. It is important to include models in the early phases of a project planning process irrespective of which types of models are used (i.e., statistical or physical). Those using the models must define the type, quantity and quality of data to be gathered remotely or in the field. Too often there is a tendency to start collecting large quantities of data before it is clear what data the models require. The data must be processed to extract needed information and stored in a user-friendly format in order that tidal, seasonal and annual environmental trends can be determined. Data from most satellites such as Landsat MSS and TM, SPOT, NOAA/AVHRR, and Nimbus/CZCS can now be analysed on interactive, user-friendly microcomputer systems. The low cost of microcomputers and networking makes it

possible to analyse much of the data at local, interactive computer terminals, as long as a central regional facility exists which manages the overall data calibration, storage and archiving. However, data archiving and information storage has often been neglected, thus impeding scientific attempts to detect long-term trends or changes in the environment.

50. Just as satellite data-receiving stations should be shared on a regional basis, major field data collection platforms (e.g., large aircraft or research vessels) should not be duplicated locally. The operating costs of four-engine aircraft and ships over 20 metres in length are extremely high. New aircraft sensors and ship instruments are being developed which can be used on smaller platforms (i.e., single/twin engine aircraft or small boats). For instance, a new multispectral solid state video camera can be mounted on a single-engine aircraft, resulting in a decrease of operating costs of from $3,000 to $150 per hour. Thus there now is an option to station less expensive equipment at local laboratories and perform more frequent flights or cruises in order to improve temporal coverage of tidal, seasonal and annual variations and long-term trends of physical and biological properties of the coastal zone.

51. Today, the use of satellite communications and navigation systems is particularly important for international shipping. Satellite technology will play a major role in future improvements of communications and navigation at sea. Recognizing the need to continuously develop and improve various elements of the maritime distress and safety system, the International Maritime Organization (IMO) has decided that in 1990 or thereabouts a new global maritime distress and safety system should be established which, in conjunction with a co-ordinated search and rescue infrastructure, will incorporate recent technical developments and significantly improve the safety of life at sea.

52. The basic concept of the Future Global Maritime Distress and Safety System (FGMDSS) is that search and rescue authorities ashore, as well as ships in the immediate vicinity of a unit in distress, will be rapidly alerted so that they can participate in a co-ordinated search and rescue operation. The planning for the future system requires co-operation with a number of international organizations, notably the International Telecommunication Union (ITU), INMARSAT and COSPAS-SARSAT.

53. The need for an accurate position-fixing system which could meet the requirements of coastal and oceanic navigation and provide services for international shipping has been recognized. Accordingly, IMO has undertaken the study of a world-wide navigation system in all sea areas in order to provide accurate positions for FGMDSS.

54. INMARSAT was established in 1978 to meet the needs of international shipping for reliable communications. The organization began global operation in February 1982, using satellite capability leased from the United States (the Marine Communications Satellite (MARISAT)), ESA (the Marine European Communications Satellite (MARECS)) and the International Telecommunications Satellite Organization (INTELSAT). INMARSAT provides a satellite communication system which makes available a full range of communications capabilities including voice, telex, data and facsimile. While INMARSAT provides the space segment - the satellites and

related tracking, telemetry, command and control facilities - shipowners are responsible for the ship Earth stations (SES). The coast Earth stations (CES) and land-line connections are the responsibility of the countries concerned. Presently, eight satellites provide mariners with a highly reliable service. Nineteen coast Earth stations, in 14 countries, provide a high degree of user choice. Thirteen manufacturers offer Standard-A SES options to meet the needs of individual users.

55. The application of space information systems in ocean science is gradually gaining ground. The study of the dynamics of the Earth system comprising the lithosphere, atmosphere, hydrosphere and biosphere at different time-scales is of particular interest in this context. Oceans and seas occupy a little over 70 per cent of the Earth's surface; they play a pivotal role in the development of the patterns of environmental systems at different time-scales. The data extracted from space information systems are being advantageously applied in the study of the geodynamics of the sea-bed, in monitoring tsunamis and the impulsively generated sea waves due to offshore earthquake events and in the study of ocean circulation, storm surge, energy flux, the distribution of chlorophyll and phytoplanktons (biota) and ocean-atmosphere interaction. Space information systems and computer data processing and presentation techniques will play a major role in the study of the processes through which ocean, land and atmosphere are linked.

56. Remote sensing techniques developed in the last decade provide powerful tools for exploring and monitoring ecological conditions of the sea surface as well as for the assessment, evaluation and management of coastal and marine resources. The marine features accessible to remote observations of the sea surface are essentially colour, temperature, texture or roughness and elevation. Such features summarize the whole of the sea surface properties - optical, thermal, structural or dynamic - which can be inferred from the interaction of electromagnetic radiation with the air/water interface. Several environmental parameters that are bio-geochemical and physical in nature can be derived from a remote assessment of these sea surface properties. Water constituents and water quality parameters, such as sea surface temperature, salinity and dynamic parameters, as well as surface winds, waves, wakes, surface films and shallow water bottom patterns, can all be assessed and quantified using remote sensors operating in suitable regions of the electromagnetic spectrum.

57. Among the various techniques available, remote sensing of sea surface colour can be particularly effective in providing large-scale, long-term data on environmental conditions. Such data have important applications in the assessment of marine biosystems and of related topics such as water quality and pollution, sediment transport and near-coastal dynamics. Variations of surface optical properties are the result of dissolved and suspended materials and the different absorption and scattering characteristics of the materials present in sea water. Visible remote sensing techniques can therefore be used to determine the presence and abundance of water constituents such as biological pigments, suspended sediments or other products of organic matter degradation (the so-called yellow substance). Since water constituents act as tracers of various marine processes, colour patterns on the sea surface can also provide indications as to the relationships between forcing mechanisms and biological responses in the marine

environment. These capabilities render optical remote sensing an attractive technique for marine ecological assessments, even though atmospheric processes and signal ambiguities in the water column may pose severe limitations to its use.

58. The feasibility and potential of passive remote sensing in the visible spectrum have been demonstrated primarily by the CZCS experiment, important results of which have been reported in the study of water quality, coastal phenomena, sediment transport, upwelling, fisheries and climatic events, and in the study of factors controlling the distribution, growth and fate of phytoplankton. On the latter topics, indications of a strong coupling between dynamic and bio-optical conditions of the marine environment are emerging from the analysis of CZCS images. Examples of such studies, carried out in open ocean regions as well as in near-coastal and enclosed basin conditions in the North Pacific and North Atlantic oceans and the Mediterranean Sea, provide clues to the unique potential of optical remote sensing for the monitoring of marine biosystems.

59. Much work still needs to be done, however, before such potential can be exploited to its fullest extent. Remote observations of the sea such as those performed by CZCS do in fact produce large quantities of data, which must pass through several levels of processing (requiring special facilities and expertise) before reaching the end user. As a consequence, a vast amount of the data available today are not utilized because the average potential user does not have the means or competence to analyse them. Such information management problems could be resolved by a marine remote sensing information system (MARSIS), which should be capable of delivering value-added remote sensing data sets both according to standard procedures and upon specific user requests. Regional MARSIS centres may be envisioned as nodal points of a distributed information system composed both of various basic modules that are devoted to such operations as data processing, management and data communication, and of related knowledge-based systems connecting the modules themselves to original data repositories and end users. These concepts may be utilized effectively by the scientific and management communities in order to fully exploit oceanographic remote sensing potentials; they may also lead to the eventual development of future oceanographic forecast services.

Annex I

PROGRAMME OF THE WORKSHOP

Date	Time	Subject	Speaker
Sunday 2 July	9-10.30 a.m.	Inaugural ceremony	
		Recitation from the Holy Qur'an	
		Welcome address by the Chairman of SUPARCO	M. Shafi Ahmad
		United Nations address	N. Jasentuliyana
		Address by Secretary General, IOMAC	H. W. Jayewardene
		Inaugural Address by the Minister for Science Technology and Petroleum and Natural Resources (Chief Guest)	Hon. Jahangir Badar
		Keynote address	
	10.30-11.15 a.m.	Marine and ocean science in the year 2000	T. Allan UNESCO (IOC)
		Technical session I	
		Chairman: H. W. Jayawardene (Sri Lanka/IOMAC)	
	2-3 p.m.	Satellite capabilities to 2000 for meteorology and hydrology	C. Barrientos (NOAA/NESDIS)
	3-4 p.m.	Remote sensing of physical and biological properties of coastal waters, estuaries and wetlands	V. Klemas (United Nations)
	4.15-5.15 p.m.	Use of ERS-1 data in the Indian Ocean region. Sea state forecasting and coastal water environmental monitoring	L. Marelli (ESA)
		Technical session II	
		Chairman: M. Ishaq Mirza (Pakistan)	
Monday 3 July	9-10 a.m.	Study of river plumes in the coastal environment and the mapping and monitoring of coral reefs	M. H. H. Ariyaratne (Sri Lanka)

Date	Time	Subject	Speaker
	10-11 a.m.	Study of coastal resources, mapping of mangroves and monitoring of mangrove degradation	A. S. Kauzeni (Tanzania)
	11.15 a.m.-12.15 p.m.	Opportunities for using GRID facilities for marine applications	D. W. Mooneyhan (UNEP-GRID)
		Technical session III	
		Chairman: M. A. K. Ngoile (Tanzania)	
	1.45-2.45 p.m.	Elements of an operational space information system including aspects of hardware/software requirements for oceanographic/marine information systems	Y. Zonov (USSR)
	2.45-3.45 p.m.	Satellite methods and applications in marine environmental analysis	C. Barrientos (NOAA/NESDIS)
	4-5 p.m.	Requirements and needed infrastructure for a viable regional marine sciences/oceanography programme	V. Klemas (United Nations)
		Technical session IV	
		Chairman: A. B. Jaffar (Malaysia)	
Tuesday 4 July	9-9.45 a.m.	Gaining access to space information systems: opportunities and problems	M. I. Mirza (Pakistan)
	9.45-10.30 a.m.	Study of time-variant and time-invariant oceanic features and phenomena through satellites	A. Farah (Pakistan)
	10.45-11.30 a.m.	Satellite survey of biosystems in the the coastal marine environment	V. Barale (FAO)
	11.30 a.m.-12.30 p.m.	Present and future developments of maritime communications and navigation systems and their roles in the Indian Ocean region	B. K. Syngal (INMARSAT)

Date	Time	Subject	Speaker
		Technical session V	
		Chairman: M. A. Sanjarani (Pakistan)	
Tuesday 4 July	9 a.m.-12.15 p.m.	Case studies: reports of national oceanographic/marine space information programmes	J. O. Z. Abuodha (Kenya) S. Jayatilake (Sri Lanka) S. H. Niaz Rizvi (Pakistan) N. M. Trimizi (Pakistan)
	2-5.30 p.m.	Case studies: reports of national oceanographic/marine space information programmes	
Wednesday 5 July	9 a.m.-noon	Working Group parallel sessions	
		Working Group A: Data availability and exchange for marine resource management	
		Chairman: E. L. S. M. Hassan (Qatar) Rapporteurs: M. O. Quader (Bangladesh) S. A. K. Alizai (Pakistan)	
		Working Group B: System requirements for the archiving and retrieval of space data	
		Chairman: J. A. Baraza (Kenya) Rapporteurs: H. A. Nasrallah (Kuwait) S. Huk (Pakistan)	
		Working Group C: Scientific co-operative mechanisms and activities in the IOMAC region	
		Chairman: M. Z. Hasan (Pakistan) Rapporteurs: H. S. Jayatilake (Sri Lanka) A. S. Kauzeni (Tanzania)	
	2-5 p.m.	Working Group A (continued)	
		Working Group B (continued)	
		Working Group C (continued)	

Date	Time	Subject	Speaker
Thursday 6 July	9 a.m.-noon	Working Group A (continued)	
		Working Group B (continued)	
		Joint working groups session Chairman: N. Jasentuliyana (United Nations)	
	2-3 p.m.	Conclusions and observations of the working groups	
	3-4 p.m.	Closing ceremony	

Annex II

MARINE INTERESTS AND SATELLITE DATA REQUIREMENTS

Parameters/ Area of study	Air/sea surface temperature	Cloud data	Wind patterns (Sea surface roughness)	Waves and currents	Humidity	Colour
1. Meteorological oceanography	4 times/day in March and Sept. at selected locations (e.g. Sumatra phenomena). All year round for monsoon phenomena.	Electronic imaging of clouds daily in the typhoon season. If a typhoon is detected then the path of typhoon should be imaged as frequently as possible until it dissipates.	4 times/day	4 times/day	4 times/day (data possibly available from GEOS and GMS)	--
2. Thermal and wave energy of the ocean	1 time/day when available.(USSR RAINEZY programme)	--	1 time/day when available	--	--	--
3. Marine pollution (a) Oil pollution	1/week. But in case of accident, as frequently as possible for the whole duration.	--	In case of accident as frequently as possible for the whole duration.	--	--	In case of accident, as frequently as possible for the whole duration.
(b) Other pollution	--	--	--	--	--	Satellite images needed
4. Migration of species	Continuously	--	--	Continously	--	There is need to develop sensors
5. Depletion of marine rascurces and degradation of ecological systems (Historical data needs to be collected)	--	--	4 times/day	--	--	Coastal zone. 4 times/year.
6. Erosion and accretion (Historical data should also be acquired)	--	--	During storms, other frequencies to be specified by users.	During storms other frequencies to be specified by users.	--	Before and after storms and floods.
7. Safety of navigation	USSR data reception continuous or as available is required for safety of navigation. Other data may be available from other sources.					

Annex III

IOMAC PROGRAMME OF INTEGRATED MARINE SPACE APPLICATION PROJECTS

A. Advantages of an integrated regional programme

1. In comparison with the existing independent national projects, a regional approach such as MSAP would provide the following:

(a) A balanced development of marine and oceanographic applications;

(b) An opportunity for the sharing of experience and the development of national skills through the IOMAC regional framework;

(c) A framework to obtain international support through IOMAC and various relevant international organizations.

2. The projects could be of a national or regional/interregional character but would essentially be implemented at the national level. Implementation would be carried out by national marine institutions or space institutions.

3. The primary elements of these projects will be co-ordinated by IOMAC in association with the participating Government and the Outer Space Affairs Division of the United Nations; other international organizations could be requested to provide:

(a) Expert advice and assistance for the implementation of the projects and their analysis and review;

(b) Assistance to obtain facilities and to facilitate the exchange of information;

(c) Assistance in obtaining imagery and processed information.

4. The selection of projects, which could include ongoing projects as well, would primarily reflect national priorities and capabilities, with due consideration to:

(a) The advantages of developing common methodologies;

(b) The exploration of new fields of applications for the benefit of Indian Ocean States;

(c) The possibilities of mobilizing the requisite national as well as international inputs in terms of data-processing facilities and expertise.

The projects would be included in the IOMAC MSAP simply by the notification to the IOMAC secretariat through the corresponding IOMAC national focal points.

B. Review workshops

Periodic reviews could be arranged for comparison of techniques and experiences as well as to assess progress.

C. Training

Training needs identified in the context of the programme could be met through appropriate regional training workshops and on-the-job training arrangements. In addition, the IOMAC fellowship programmes could assist in providing short-term ad hoc training.

D. Oceanographic and coastal research projects using remote sensing which are important to the IOMAC region and are likely to succeed

	Topic and objective	Platform and sensors	Application of results
1.	Seasonal variations of current circulation in the northern Indian Ocean	NOAA AVHRR GEOSAT altimeter ERS-I altimeter EOS MODIS	Influence of current circulation on climate, fisheries and pollution dispersion
2.	Dynamics of upwelling events along Somalia coast, northern Arabian Sea and near Maldives	NOAA AVHRR Sea-WIFs EOS MODIS, CZCS	Monitoring and predictive modelling of fisheries productivity to increase and manage fisheries
3.	Coastal land use change and mangrove degradation	SPOT Landsat TM EOS HIRIS, MOS	To improve management of mangroves for maximum biological productivity
4.	Coastal erosion and sediment transport	Landsat TM SPOT, aircraft MSS, EOS HIRIS, MOS, CZCS	To develop strategy for protecting beaches from erosion and ship channels from siltation
5.	Sources, drift and dispersion of coastal pollution	Landsat TM aircraft SPOT, MOS EOS HIRIS, CZCS	To improve regulations against pollution effluents and dumping
6.	Seasonal variations and wave conditions in the northern Indian Ocean	GEOSAT altimeter ERS I scattrometer ERS-I SAR ERS-I altimeter EOS SAR	To monitor wind and wave conditions and develop prediction models leading to improved protection of beaches, coastal structures and shipping

Annex IV

A PILOT PROJECT FOR THE INDIAN OCEAN REGION (IOMAC/NOAA)

1. Examine satellite data archive and select eight images or series of images for the different seasons of the year for a two-year period (two sets of seasonal data for the year of the great El Niño plus a "normal year"; total of eight images to show differing features). Images or series of images in case of cloudy situation to do composite.

2. Analyse the data.

3. Publish the report

Timing consideration for selection of images

(a) Winter or coldest month;

(b) Summer or warmest;

(c) Spring transition period;

(d) Fall transition period.

What will be learned, or expected product

(a) Understanding the region in the context of modern data processing. GRID for the study will be set up. Data base for geography will be established, including coastal geometry in digitalized form, bathymetry and climatology.

(b) We will know if remote sensing data will be useful to us with regard to:

(i) Sea surface temperature;

(ii) Ocean colour;

(c) We will find out: ocean structures, currents, fronts, runoffs, reefs;

(d) Some of the questions that can be answered:

(i) Satellite data useful? availability?

(ii) Any interesting information?

(iii) Is further study warranted (i.e., significant thermal fronts, upwelling regions, step function type water colour changes, major river sediment plume behaviour, significant pollution sources)?

(e) Recommendations (e.g. identify and recommend two to four follow-up investigations for IOMAC countries to pursue);

(f) Project based at NOAA to be carried out with a team of 8 to 10 visiting remote sensing specialists to be selected on a geographic representative basis from IOMAC member States;

(g) Experience (credibility):

(i) Eastern Pacific - El Niño;

(ii) West coast of Africa;

(iii) Philippines;

(iv) Antarctic;

(v) Fiji and Kiribati;

(vi) African lakes - Kariba and others;

(vii) Somali current study;

(h) Co-ordination of project: C. Barrientos (United States, NOAA).

Annex V

SOME POSSIBLE IOMAC MSAP PROGRAMMES

Co-operating agency	Area and/or object of interest for collaboration in the Indian Ocean region
INMARSAT	Distress and safety related matters
	Search and rescue matters
	Collection of data from the marine environment
	Flood forecasting and data collection at key places in the country
	Interactive communications between data centres and users
	Dissemination of navigational and meteorological data to fishing fleets or other users
	Providing communications in emergency relief observation
	Thin route remote sensing communication applications for voice, telex, data transfer, etc.
	Training of experts from Developing Countries Programme
UNEP GRID (regional centres at Nairobi and Bangkok)	Provision of data available in GRID system
	Assistance with data entry and data processing
	Provision of consultant on request for specific project
United Nations (FAO)	Coastal zone use and management
	Aquaculture potentials, development monitoring

Co-operating agency	Area and/or object of interest for collaboration in the Indian Ocean region
	Environmental assessments of near-coastal areas in general (e.g., anthropogenic impact on circulation features, biosystem, etc.) Fisheries: Evaluation of potentials Fishing grounds Operation support, etc.
Space Data Research Centre of Fisheries (USSR)	Sea surface temperature maps for fishing Applications and general oceanography

---